Charles Darwin University

Final Examination

Family Name						
Given Name/s						
Student Number						
Teaching Period	Semester 1, 2018					

ENG442 – Chemical Engineering Thermodynamics	DURATION	
	Reading Time:	10 minutes
	Writing Time:	120 minutes

INSTRUCTIONS TO CANDIDATES

1. Read all questions carefully.
2. Answer ALL questions.
3. Show all working (calculations and sketches).
4. This exam constitutes 50% of the total marks for this Unit.
5. Total marks available on this exam = 100.
6. Use dark blue or black ink.

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a RESTRICTED OPEN BOOK examination

Any non-programmable calculator is permitted

One A4 sheet of handwritten double-sided notes permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	EXAMINATION MATERIALS TO BE SUPPLIED
None	1 x 20 Page Book Reference Information

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1

In an ideal vapour-compression refrigeration cycle, refrigerant R-12 enters the compressor as a saturated vapour at -20 ℃ and leaves the condenser as a saturated liquid at 30 ℃. The mass flow rate of the refrigerant is $0.6\ {}^{kg}/_{s}$. Calculate

- the refrigeration effect (rate of refrigeration or heat transfer rate in the evaporator)

(Marks: 4)

- power consumed by the compressor

(Marks: 4)

- the coefficient of performance of the refrigerator

(Marks: 4)

- quality of the refrigerant after the expansion valve

(Marks: 4)

- heat transfer rate in the condenser

(Marks: 4)

Assumption: The pressure drop in the evaporator and the condenser are negligible

Thermodynamic data for refrigerant R-12 is given in the reference information

Question 2

The vapour pressure of acetone (1), acetonitrile (2) and nitromethane(3) can be calculated by using the Antoine equation

$$Ln(P^{sat}) = A - \frac{B}{T + C}$$

Where P^{sat} are in kPa and T is in ℃.

Calculate the pressure and composition of the gas phase at equilibrium with a liquid mixture at 75 ℃ with the following composition $x_1 = 0.3$ and $x_2 = 0.4$. Assume that the mixture is an ideal mixture that follows Raoult's law.

	A	B	C
Acetone	14.3916	2795.82	230.0
Acetonitrile	14.2724	2945.47	224.0
Nitromethane	14.2043	2972.64	209.0

(15 marks)

Question 3

A vessel is divided into two parts by a partition, contains 10 mol of CO_2 gas at $75\ ℃$ and 30 bar on one side and 5 mol Ar gas at $130\ ℃$ and 20 bar on the other. If the partition is removed and the gases mix adiabatically and completely, calculate:

a) The total entropy change of CO_2

(10 marks)

b) The total entropy change of Ar

(10 marks)

c) The total entropy change of the process.

(15 marks)

Assume that both gases are ideal. The heat capacities at constant volume for CO_2 and Ar are (5/2)R and (3/2)R, respectively.

Question 4

An equimolar mixture of $CO_{(g)}$ and $H_2O_{(g)}$ enters a reactor which is maintained at 10 bar and 1000K. the reaction involved is

$$CO_{(g)} + H_2O_{(g)} \rightarrow CO_{2(g)} + H_{2(g)}$$

Give that the equilibrium constant K_P for this reaction at 1000K is 1.5. Calculate the composition of the gas mixture leaving the reactor. Assume that all gases follow the ideal gas law.

(30 marks)

Conversion Factor Table

http://www.et.byu.edu/~jww8

	Multiple	by	To Get
	inch	**2.54**	**cm**
	This can also be written as: 1 inch = 2.54 cm		
A	acre	43,560	ft^2
	ampere·hr (A·h)	3,600	coulomb (C)
	ångström (Å)	$1x10^{-10}$	m
	atm (atmosphere)	1.01325	bar
	atm, std	76.0	cm of Hg
	atm, std	760	mm of Hg at 0°C
	atm, std	33.90	ft of water
	atm, std	29.92	in of Hg at 30°F
	atm, std	14.696	lbf/in^2 abs (psia)
	atm, std	101.325	kPa
	atm, std	$1.013x10^5$	Pa
	atm, std	1.03323	kgf / cm^2
	atm, std	14.696	psia
B	bar	0.9869	atm, std
	bar	$1x10^5$	Pa
	Btu	778.169	ft·lbf
	Btu	1055.056	J
	Btu	5.40395	psia·ft^3
	Btu	$2.928x10^{-4}$	kWh
	Btu	$1x10^{-5}$	therm
	Btu / hr	1.055056	kJ / hr
	Btu / hr	0.216	ft·lbf / sec
	Btu / hr	$3.929x10^{-4}$	hp
	Btu / hr	0.2931	W
	Btu / lbm	2.326*	kJ / kg
	Btu / lbm	25,037	ft^2 / s^2
	Btu / lbm·R	4.1868	kJ / kg·K
	Btu / lbm·°F	4.1868	kJ / kg·°C
	Btu / lbmol·R	4.1868	kJ / kmol·K
C	cal (g-calorie)	$3.968x10^{-3}$	Btu
	cal	$1.560x10^{-6}$	hp·hr
	cal (IT calorie)	4.1868	J
	Calorie (Cal)	4.1868	kJ
	cal / sec	4.1868	W (watt)
	cm (centimeter)	0.03281	ft
	cm	0.3937	in
	cP (centipoise)	0.001	Pa·sec
	cSt (centistokes)	$1x10^{-6}$	m^2 / sec
D	degree	π/180	radian
	dyne	10	μN (micronewton)
E	eV (electronvolt)	$1.602x10^{-19}$	J
	erg	$1x10^{-7}$	J
F	ft (feet)	0.3048*	m
	ft	30.48	cm
	ft^2	$2.2957x10^{-5}$	acre
	ft^2	144	in^2
	ft^2	0.09290304*	m^2
	ft^3	7.481	gal (U.S.)
	ft^3	0.02832	m^3
	ft^3	28.317	L
	ft^3 / lbm	0.062428	m^3 / kg
	ft·lbf	$1.285x10^{-3}$	Btu
	ft·lbf	1.35582	J
	ft·lbf	$3.766x10^{-7}$	kWh
	ft·lbf	1.35582	N·m
	ft·lbf	0.324	calorie (g-cal)
	ft·lbf / sec	$1.818x10^{-3}$	hp
	ft / s^2	0.3048*	m / s^2
G	U.S. gallon (gal)	0.13368	ft^3
	gal	3.7854	L
	gal	$3.7854x10^{-3}$	m^3
	gal	231	in^3
	gal (U.K.)	1.201	gal (U.S.)
	gal (U.K.)	277.4	in^3
	gal / min (gpm)	0.002228	ft^3 / sec
	gamma (γ,Γ)	$1x10^{-9}$	tesla (T)
	gauss	$1x10^{-4}$	T
	gram (g)	$2.205x10^{-3}$	lbm
	g / cm^3	1	1 kg / L
	g / cm^3	1000	kg / m^3
	g / cm^3	62.428	lbm / ft^3
	g / cm^3	1.940	slug / ft^3
	g / cm^3	0.036127	lbm / in^3
H	hectare	$1x10^4$	m^2
	hectare	2.47104	acres
	hp (horsepower)	42.41	Btu / min
	hp	0.7068	Btu / sec
	hp	2544.5	Btu / hr
	hp	745.70	W (watt)
	hp	0.74570	kW
	hp	33,000	ft·lbf / min
	hp	550	ft·lbf / sec
	hp·hr	2544	Btu
	hp·hr	$1.98x10^6$	ft·lbf
	hp·hr	$2.68x10^6$	J
	in	2.54*	cm
	in of Hg	0.0334	atm
	in of Hg	13.60	in of water
	in of Hg	3.387	kPa
	in of water	0.0736	in of Hg
	in of water	0.0361	lbf / in^2 (psi)
	in of water	0.002458	atm
J	J (joule)	$9.4782x10^{-4}$	Btu
	J	$6.2415x10^{18}$	eV
	J	0.73756	ft·lbf
	J	1	N·m
	J	$1x10^7$	ergs
	J / s	1	W
K	kg (kilogram)	2.2046226	lbm (pound mass)
	kg	0.068522	slug
	kg	$1x10^{-3}$	metric ton
	kg / m^3	0.062428	lbm / ft^3
	kgf	9.80665	newton (N)
	kip	1000	lbf
	kip	4448	N
	kJ	1	1 kPa·m^3
	kJ	1000	N·m
	kJ	0.94782	Btu
	kJ	737.56	ft·lbf
	kJ / kg	1000	m^2 / s^2
	kJ / kg	0.42992	Btu / lbm
	kJ / kg·K	0.23885	Btu / lbm·°R
	kJ / kg·°C	1	kJ / kg·K
	kJ / kg·°C	1	J / g·°C
	kJ / kg·°C	0.23885	Btu / lbm·°F
	kJ / kg·°C	0.23885	Btu / lbm·R
	km	3280.8	ft
	km	0.6214	mi
	km/hr	0.6214	mi / hr (mph)
	km/hr	0.2778	m/s
	km/hr	0.9113	ft/s
	kPa (kilopascal)	$9.8693x10^{-3}$	atm
	kPa	0.14504	lbf / in^2 (psi)
	kW	3412.14	Btu / hr
	kW	0.9478	Btu / sec
	kW	737.56	lbf·ft / sec
	kW	1.341	hp
	kWh (kW-hour)	3412.14	Btu
	kWh	1.341	hp·hr
	kWh	3600	kJ
L	L (liter)	0.03531	ft^3
	L	61.02	in^3
	L	0.2642	gal (U.S.)
	L	0.001	m^3
	L / s	2.119	ft^3 / min (cfm)
	L / s	15.85	gal / min (gpm)
	lbf (pound force)	32.174	lbm·ft / s^2
	lbf	4.44822	N
	lbf	32.17	poundals
	lbf / in^2 (psi)	0.06805	atm
	lbf / in^2	2.307	ft water
	lbf / in^2	2.036	in Hg
	lbf / in^2	6894.757	Pa
	lbm	0.45359237*	kg
	lbm	0.031081	slug
	lbm / in^3	1728	lbm / ft^3
	lbm / ft^3	0.016018	g / cm^3
	lbm / ft^3	16.018	kg / m^3
M	m (meter)	3.28083	ft
	m	1.0926	yard
	m	39.370	in
	m^2	1550	in^2
	m^2	10.764	ft^2
	m^3	$1x10^6$	cm^3 (cc)
	m^3	35.315	ft^3
	m^3	264.17	gal (U.S.)
	m^3	1000	L
	m^3 / kg	16.02	ft^3 / lbm
	m / s	196.8	ft / min
	m / s	3.60	km / h
	m / s	3.2808	ft / s
	m / s	2.237	mi / h (mph)
	m / s^2	3.2808	ft / s^2
	metric ton	1000	kg
	mil	0.001	in
	mi (mile)	5280	ft
	mi	1.6093	km
	mi^2 (square mile)	640	acres
	mph (mile/hour)	1.6093	km / hr
	mph	88.0	ft / min (fpm)
	mph	1.467	ft / s
	mph	0.4470	m / s
	micron	$1x10^{-6}$	m
	mm of Hg	$1.316x10^{-3}$	atm
	mm of Hg	0.1333	kPa
	mm of water	$9.678x10^{-5}$	atm
N	N (newton)	1	kg·m / s^2
	N	$1x10^5$	dyne
	μN (microN)	0.1	dyne
	N	0.22481	lbf
	N·m	0.7376	ft·lbf
	N·m	1	J
P	Pa (pascal)	1	N / m^2
	Pa	$1.4504x10^{-4}$	lbf / in^2 (psia)
	Pa	0.020886	lbf / ft^2
	Pa	$9.869x10^{-6}$	atm
	Pa·s	10	poise
	psi (pounds per square inch) --- see lbf / in^2		
R	radian	180/π	degree
S	short ton	2000	lbm
	short ton	907.1847	kg
	slug	32.174	lbm
	slug	14.5939	kg
	slug / ft^3	0.5154	g / cm^3
	stokes	$1x10^{-4}$	m^2 / s
T	therm	$1x10^5$	Btu
	ton of refrigeration	200	Btu / min
W	W (watt)	3.4121	Btu / hr
	W	0.7376	ft·lbf / sec
	W	$1.341x10^{-3}$	hp
	W	1	J / s
	W / cm^2	$1x10^4$	W / m^2
	W / cm^3	$1x10^6$	W / m^3
	W / m^2	0.3171	Btu / (h·ft^2)
	W / m^3	0.09665	Btu / (h·ft^3)
	W / m·°C	1	W / m·K
	W / m·°C	0.57782	Btu / (h·ft·°F)
	W / (m^2·°C)	1	W / (m^2·K)
	W / (m^2·°C)	0.17612	Btu / (h·ft^2·°F)
	weber / m^2	10,000	gauss

* The exact conversion between metric and English.

TEMPERATURE

$T(K) = T(°C) + 273.15$

$T(R) = T(°F) + 459.67$

$T(°F) = 1.8\ T(°C) + 32$

SOME IMPORTANT CONSTANTS

Atomic Mass Unit (u)	=	$1.66054x10^{-27}$ kg
Avogadro's number (N_A)	=	$6.02213x10^{23}$ particles/mol
Boltzmann's constant (k_B)	=	$1.38065x10^{-23}$ J / K
electron charge (e)	=	$-1.6022x10^{-19}$ C
electron mass (m_e)	=	$9.10939x10^{-31}$ kg
proton mass (m_p)	=	$1.6726x10^{-27}$ kg
Gas Constant (R)	=	8314 J / kmol·K
Gravitational Constant (G)	=	$6.672x10^{-11}$ N·m^2 / kg^2
Gravity (mean)	=	9.8067 (9.81) m / s^2
Planck's constant (h)	=	$6.6260x10^{-34}$ J·s
Speed of Light (c)	=	$2.99792458x10^8$ m/s (exact)

SI PREFIXES

yocto (10^{-24}), zepto (10^{-21}), atto (10^{-18}), femto (10^{-15}), pico (10^{-12}), nano (10^{-9}), micro (10^{-6}), milli (10^{-3}), centi (10^{-2}), deci (10^{-1}), deka (10^1), hecto (10^2), kilo (10^3), mega (10^6), giga (10^9), tera (10^{12}), peta (10^{15}), exa (10^{18}), zetta (10^{21}), yotta (10^{24})

Thermodynamic properties of saturated Refrigerant R-12

Temp. (°C)	Press. (kPa)	Specific Volume, m^3/kg			Internal Energy, kJ/kg		
		Sat. Liquid v_f	Evap. v_{fg}	Sat. Vapor v_g	Sat. Liquid u_f	Evap. u_{fg}	Sat. Vapor u_g
−90	2.8	0.000608	4.41494	4.41555	−43.29	177.20	133.91
−80	6.2	0.000617	2.13773	2.13835	−34.73	172.54	137.82
−70	12.3	0.000627	1.12665	1.12728	−26.14	167.94	141.81
−60	22.6	0.000637	0.63727	0.63791	−17.50	163.36	145.86
−50	39.1	0.000648	0.38246	0.38310	−8.80	158.76	149.95
−45	50.4	0.000654	0.30203	0.30268	−4.43	156.44	152.01
−40	64.2	0.000659	0.24125	0.24191	−0.04	154.11	154.07
−35	80.7	0.000666	0.19473	0.19540	4.37	151.77	156.13
−30	100.4	0.000672	0.15870	0.15937	8.79	149.40	158.19
−29.8	101.3	0.000672	0.15736	0.15803	8.98	149.30	158.28
−25	123.7	0.000679	0.13049	0.13117	13.24	147.01	160.25
−20	150.9	0.000685	0.10816	0.10885	17.71	144.59	162.31
−15	182.6	0.000693	0.09033	0.09102	22.20	142.15	164.35
−10	219.1	0.000700	0.07595	0.07665	26.72	139.67	166.39
−5	261.0	0.000708	0.06426	0.06496	31.26	137.16	168.42
0	308.6	0.000716	0.05467	0.05539	35.83	134.61	170.44
5	362.6	0.000724	0.04676	0.04749	40.43	132.01	172.44
10	423.3	0.000733	0.04018	0.04091	45.06	129.36	174.42
15	491.4	0.000743	0.03467	0.03541	49.73	126.65	176.38
20	567.3	0.000752	0.03003	0.03078	54.45	123.87	178.32
25	651.6	0.000763	0.02609	0.02685	59.21	121.03	180.23
30	744.9	0.000774	0.02273	0.02351	64.02	118.09	182.11
35	847.7	0.000786	0.01986	0.02064	68.88	115.06	183.95
40	960.7	0.000798	0.01737	0.01817	73.82	111.92	185.74
45	1084.3	0.000811	0.01522	0.01603	78.83	108.66	187.49
50	1219.3	0.000826	0.01334	0.01417	83.93	105.24	189.17
55	1366.3	0.000841	0.01170	0.01254	89.12	101.66	190.78
60	1525.9	0.000858	0.01025	0.01111	94.43	97.88	192.31
65	1698.8	0.000877	0.00897	0.00985	99.87	93.86	193.73
70	1885.8	0.000897	0.00783	0.00873	105.46	89.56	195.03
75	2087.5	0.000920	0.00680	0.00772	111.23	84.94	196.17
80	2304.6	0.000946	0.00588	0.00682	117.21	79.90	197.11
85	2538.0	0.000976	0.00503	0.00600	123.45	74.34	197.80
90	2788.5	0.001012	0.00425	0.00526	130.02	68.12	198.14
95	3056.9	0.001056	0.00351	0.00456	137.01	60.98	197.99
100	3344.1	0.001113	0.00279	0.00390	144.59	52.48	197.07
105	3650.9	0.001197	0.00205	0.00324	153.15	41.58	194.73
110	3978.5	0.001364	0.00110	0.00246	164.12	24.08	188.20
112.0	4116.8	0.001792	0	0.00179	176.06	0	176.06

Temp. (°C)	Press. (kPa)	Enthalpy, kJ/kg			Entropy, kJ/kg-K		
		Sat. Liquid h_f	Evap. h_{fg}	Sat. Vapor h_g	Sat. Liquid s_f	Evap. s_{fg}	Sat. Vapor s_g
−90	2.8	−43.28	189.75	146.46	−0.2086	1.0359	0.8273
−80	6.2	−34.72	185.74	151.02	−0.1631	0.9616	0.7984
−70	12.3	−26.13	181.76	155.64	−0.1198	0.8947	0.7749
−60	22.6	−17.49	177.77	160.29	−0.0783	0.8340	0.7557
−50	39.1	−8.78	173.73	164.95	−0.0384	0.7785	0.7401
−45	50.4	−4.40	171.68	167.28	−0.0190	0.7524	0.7334
−40	64.2	0	169.59	169.59	0	0.7274	0.7274
−35	80.7	4.42	167.48	171.90	0.0187	0.7032	0.7219
−30	100.4	8.86	165.34	174.20	0.0371	0.6799	0.7170
−29.8	101.3	9.05	165.24	174.29	0.0379	0.6790	0.7168
−25	123.7	13.33	163.15	176.48	0.0552	0.6574	0.7126
−20	150.9	17.82	160.92	178.74	0.0731	0.6356	0.7087
−15	182.6	22.33	158.64	180.97	0.0906	0.6145	0.7051
−10	219.1	26.87	156.31	183.19	0.1080	0.5940	0.7019
−5	261.0	31.45	153.93	185.37	0.1251	0.5740	0.6991
0	308.6	36.05	151.48	187.53	0.1420	0.5545	0.6965
5	362.6	40.69	148.96	189.65	0.1587	0.5355	0.6942
10	423.3	45.37	146.37	191.74	0.1752	0.5169	0.6921
15	491.4	50.10	143.68	193.78	0.1915	0.4986	0.6902
20	567.3	54.87	140.91	195.78	0.2078	0.4806	0.6884
25	651.6	59.70	138.03	197.73	0.2239	0.4629	0.6868
30	744.9	64.59	135.03	199.62	0.2399	0.4454	0.6853
35	847.7	69.55	131.90	201.45	0.2559	0.4280	0.6839
40	960.7	74.59	128.61	203.20	0.2718	0.4107	0.6825
45	1084.3	79.71	125.16	204.87	0.2877	0.3934	0.6811
50	1219.3	84.94	121.51	206.45	0.3037	0.3760	0.6797
55	1366.3	90.27	117.65	207.92	0.3197	0.3585	0.6782
60	1525.9	95.74	113.52	209.26	0.3358	0.3407	0.6765
65	1698.8	101.36	109.10	210.46	0.3521	0.3226	0.6747
70	1885.8	107.15	104.33	211.48	0.3686	0.3040	0.6726
75	2087.5	113.15	99.14	212.29	0.3854	0.2847	0.6702
80	2304.6	119.39	93.44	212.83	0.4027	0.2646	0.6672
85	2538.0	125.93	87.11	213.04	0.4204	0.2432	0.6636
90	2788.5	132.84	79.96	212.80	0.4389	0.2202	0.6590
95	3056.9	140.23	71.71	211.94	0.4583	0.1948	0.6531
100	3344.1	148.31	61.81	210.12	0.4793	0.1656	0.6449
105	3650.9	157.52	49.05	206.57	0.5028	0.1297	0.6325
110	3978.5	169.55	28.44	197.99	0.5333	0.0742	0.6076
112.0	4116.8	183.43	0	183.43	0.5689	0	0.5689

Taken from Sonntag, Richard Edwin, C. Borgnakke, Gordon J. Van Wylen, and Gordon J. Van Wylen. *Fundamentals of Thermodynamics*. New York: Wiley, 1998.

Thermodynamic properties of super-heated Refrigerant R-12

P=0.7 MPa					P=0.8 MPa					P=0.9 MPa				
T °C	v m^3/kg	h kJ/kg	u kJ/kg	s kJ/(kg·K)	T °C	v m^3/kg	h kJ/kg	u kJ/kg	s kJ/(kg·K)	T °C	v m^3/kg	h kJ/kg	u kJ/kg	s kJ/(kg·K)
27.81	0.024913	198.80	181.36	0.6860										
30	0.025354	200.46	182.71	0.6917	32.88	0.021811	200.67	183.23	0.6845	37.58	0.019327	202.36	184.96	0.6832
40	0.026761	207.72	188.99	0.7153	40	0.022831	206.07	187.80	0.7021	40	0.019745	204.31	186.54	0.6897
50	0.028100	214.90	195.23	0.7378	50	0.024068	213.44	194.18	0.7253	50	0.020912	211.91	193.09	0.7136
60	0.029387	222.01	201.44	0.7595	60	0.025247	220.71	200.51	0.7474	60	0.022013	219.37	199.55	0.7363
70	0.030632	229.09	207.65	0.7804	70	0.026380	227.93	206.82	0.7688	70	0.023063	226.72	205.97	0.7581
80	0.031843	236.16	213.87	0.8008	80	0.027477	235.11	213.12	0.7894	80	0.024073	234.02	212.35	0.7790
90	0.033027	243.24	220.12	0.8205	90	0.028545	242.27	219.44	0.8094	90	0.025052	241.28	218.74	0.7993
100	0.034189	250.32	226.39	0.8398	100	0.029588	249.44	225.76	0.8289	100	0.026005	248.53	225.13	0.8190
110	0.035332	257.43	232.70	0.8585	110	0.030612	256.61	232.12	0.8478	110	0.026937	255.77	231.53	0.8382
120	0.036458	264.56	239.04	0.8769	120	0.031619	263.80	238.50	0.8664	120	0.027852	263.02	237.96	0.8568
130	0.037571	271.72	245.42	0.8949	130	0.032612	271.01	244.92	0.8845	130	0.028751	270.29	244.41	0.8751
140	0.038673	278.92	251.85	0.9125	140	0.033592	278.25	251.38	0.9022	140	0.029639	277.58	250.90	0.8929
150	0.039764	286.15	258.31	0.9298	150	0.034563	285.52	257.87	0.9196	150	0.030515	284.89	257.42	0.9104
160	0.040847	293.41	264.82	0.9468	160	0.035524	292.82	264.40	0.9366	160	0.031382	292.23	263.98	0.9276
170	0.041922	300.72	271.37	0.9635	170	0.036477	300.16	270.98	0.9534	170	0.032241	299.60	270.58	0.9444
180	0.042990	308.06	277.97	0.9799	180	0.037424	307.53	277.59	0.9698	180	0.033093	307.00	277.21	0.9609
190	0.044053	315.45	284.61	0.9960	190	0.038364	314.94	284.25	0.9860	190	0.033939	314.43	283.89	0.9771
200	0.045110	322.87	291.29	1.0118	200	0.039299	322.39	290.95	1.0019	200	0.034779	321.90	290.60	0.9931
210	0.046163	330.33	298.01	1.0274	210	0.040230	329.87	297.68	1.0176	210	0.035615	329.40	297.35	1.0088
220	0.047211	337.82	304.78	1.0428	220	0.041156	337.38	304.46	1.0330	220	0.036446	336.94	304.14	1.0242
230	0.048256	345.36	311.58	1.0579	230	0.042078	344.94	311.28	1.0481	230	0.037273	344.51	310.97	1.0394

Taken from
https://www.egr.msu.edu/classes/me201/somerton/R12Tables.pdf